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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 948

WARHEADS FOR AIR TARGET GUIDED MISSILES;
TESTING OF

40th Partial Report

AAP ROD-PRODUCING WARHEAD AND
ROCKET MOTOR; FRAGMENTATION OF

FINAL Report

Copy No. 11

Task
Assignment NPG-Re3f-607-1-52

Classification CONFIDENTIAL
SECURITY INFORMATION

NPG REPORT NO. 948

AAP Rod-Producing Warhead and Rocket Motor, Fragmentation of

PART A

SYNOPSIS

1. This test was conducted to determine the fragmentation characteristics of AAP rod-producing warheads. These warheads were made from NE 8737 steel tubing, internally grooved, heat treated to Rockwell "C" 40-44, and Composition C-3 loaded.

2. The AAP warhead expelled rod-like fragments up to 8" in length evenly about the warhead circumference at an average velocity of 4160 ft./sec.

AAP Rod-Producing Warhead and Rocket Motor, Fragmentation of

TABLE OF CONTENTS

AAP Rod-Producing Warhead and Rocket Motor, Fragmentation of

PART I

INTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a) and conducted under Task Assignment NPG-Re3f-607-1-52, reference (b).

2. REFERENCES:

a. NOL Conf ltr NP/NOL/X11(270) WG:SW:mbw Ser 01569 of 6 September 1951
b. BUORD Conf ltr NP9 Re3f-EJHL:edb Ser 25777 of 18 September 1951
c. NPG Conf Report No. 858 of 13 October 1951
d. NPG Conf Report No. 854 of 1 September 1951

3. BACKGROUND:

a. Reference (b) authorized the Naval Ordnance Laboratory to work directly with the Naval Proving Ground in the development and testing of guided missile warheads.

b. Reference (d) reported the fragmentation characteristics of the notched ring AAP warhead. Reference (c) reported the fragment mass distribution of two types of AAP rod-producing warheads, Type 4. Four additional AAP rod-producing warheads, were delivered to the Proving Ground for fragmentation tests.

4. OBJECT OF TEST:

This test was conducted to determine the fragmentation characteristics of AAP rod-producing warheads. These warheads were made from NE 8737 steel tubing, internally grooved, heat treated to Rockwell "C" 40-44, and Composition C-3 loaded.

5. PERIOD OF TEST:

a.	Date Project Letter	6 September 1951
b.	Date Necessary Material Received	27 September 1951
c.	Date Commenced Test	5 December 1951
d.	Date Test Completed	7 December 1951

6. REPRESENTATIVES PRESENT:

This test was witnessed by Messrs. S. Wolf and J. R. Burton representing the Naval Ordnance Laboratory.

PART C

DETAILS OF TEST

7. DESCRIPTION OF ITEM UNDER TEST:

Four rounds of AAP rod-producing warheads were assembled with inert AAP rocket motors. Detailed assemblies are shown in Figures 1, 2, and 3. The warheads were made from NE 8737 steel tubing, internally grooved to produce 24 rod-like fragments and heat treated to Rockwell "C" 40-44. The warheads were assembled with mock-up VT fuzes modified for static detonation and then loaded with Composition C-3 at the Proving Ground. The weights of the components were as follows:

Rd. No.	Serial No.	Motor Wt. lbs.	Head Wt. with Fuze lbs.	Filler Wt. lbs.	Total Wt. lbs.
1	505-1	38.85	17.10	4.60	60.55
2	505-2	38.75	17.10	4.61	60.46
3	505-3	38.80	17.32	4.46	60.58
4	505-4	38.80	17.15	4.50	60.45

8. PROCEDURE:

a. Round No. 1, Serial No. 505-1, was detonated in a sawdust filled chamber for mass distribution data. After the detonation, the sawdust was sifted and the fragments recovered by the use of sieves and a magnetic separator.

b. Rounds Nos. 2, 3, and 4, Serials Nos. 505-2, 505-3, and 505-4, were detonated in a 30.6 foot radius velocity arena. The arena consisted of 15 foot high 1" thick steel panels in longitude zones 350°-55° and 125°-190°. A cane fiberboard pack 4' high 8' wide, and 4' thick was placed with its center 5 feet off the ground, in the 90° longitudinal plane, and 30.6 feet from the center of the arena for recovery of sample rod-like fragments. The velocity determinations were obtained by high speed photographic technique. Angular fragment distribution and fragment lengths were recorded from impacts on the panels. All rounds were placed vertically with the warhead up on a wooden stand in the center of the arena and detonated statically.

9. RESULTS AND DISCUSSION:

a. Mass Distribution

Detailed mass distribution data of Round No. 1, Serial No. 505-1 are listed in Table IV and shown in Figure 4. The number and lengths of the rod-like fragments are as follows:

No.	Approx. Size	No.	Approx. Size
10	8"	6	4 1/2"
2	6"	27	2" - 4"

The motor fragmented satisfactorily, considering that it contained no propellant.

b. Fragment Space Distribution

One of the three warheads detonated for space distribution and velocity detonated low order. The warhead is shown in Figure 6. The other two detonated high order producing rod-like fragments. The fragments were distributed evenly, approximately 15° apart about the circumference of the warhead at approximately 93° of latitude measured from the forward end of the missile. The rocket motor is the forward end of this missile with the warhead the base end. The rod-like fragments had a tendency to remain about 6" to 8" in length with some breaking into two lengths. Detailed fragment length and angular distribution data are listed in Table I. Sample warhead and motor fragments recovered are shown in Figures 5 and 7.

c. Fragment Velocities

The rod-like fragment velocity from the warheads 505-2 and 505-3 averaged 4160 ft./sec. The motor fragments which hit in latitude zone 75°-78° averaged 2500 ft./sec. These fragments were from the rear section of the motor nearest the warhead. The major portion of the motor fragments were found within 400 feet of the arena center and their velocity is estimated to be 200-500 ft./sec. Detailed fragment velocity data are listed in Tables II and III.

PART D

CONCLUSIONS

10. The AAP warhead expelled rod-like fragments up to 8" in length evenly about the warhead circumference at an average velocity of 4160 ft./sec.

AAP Rod-Producing Warhead and Rocket Motor, Fragmentation of

The tests upon which this report is based were conducted by:
V. PHILIPCHUK, Fragmentation Battery Officer,
Fragmentation Division,
Terminal Ballistics Department

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Terminal Ballistics Department
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APPROVED: IRVING T. DUKE
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Commander, Naval Proving Ground

C. T. MAURO
Captain, USN
Ordnance Officer
By direction

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NPG REPORT NO. 948

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Fortieth Partial Report

on

Warheads for Air Target Guided Missiles;

Testing of

- -

Final Report

on

AAP Rod-Producing Warhead and

Rocket Motor; Fragmentation of

Project No.: NPG-Re3f-607-1-52
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Date: MAR 27 1952

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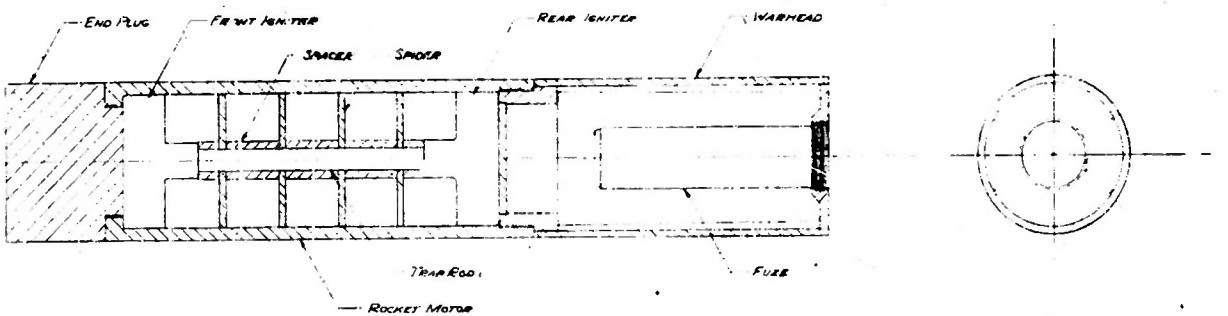
BuOrd Drawing SK 315165. Outline Drawing of AAR Warhead and Rocket Motor.
Figure 1



SK 315165

AAR TRIAL WARHEAD
TYPE No. 1
TEST ASSEMBLY

DO NOT SCALE THIS DRAWING

MATERIAL

SCALE 1/2

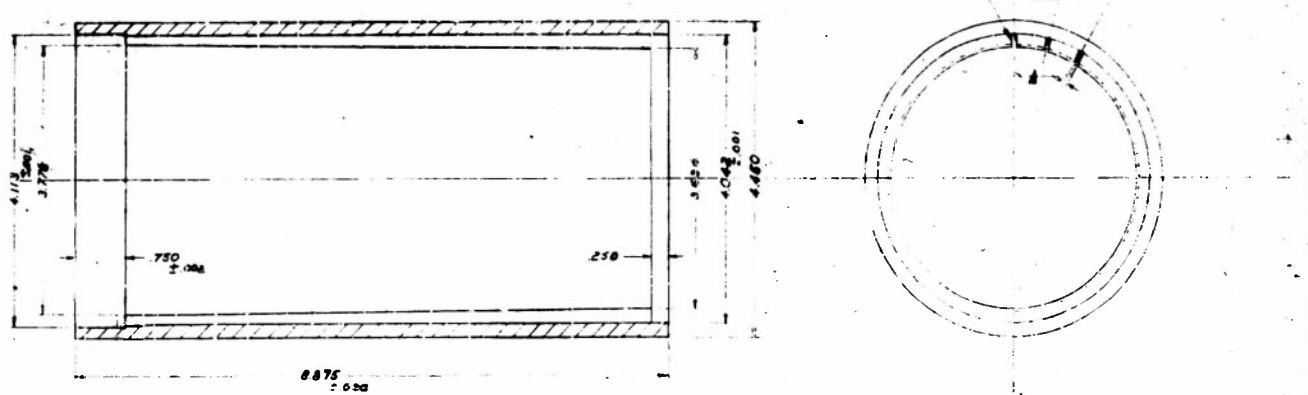
U. S. NAVAL ORDNANCE LABORATORY

BUORD DRAWING NO. SK 315165

NP9-47488 5 December 1951 CONFIDENTIAL SECURITY INFORMATION

BuOrd Drawing SK 315753. AAP Rod-producing Warhead.

Figure 5



TAPER OF INSIDE WALL = .009 PER IN.

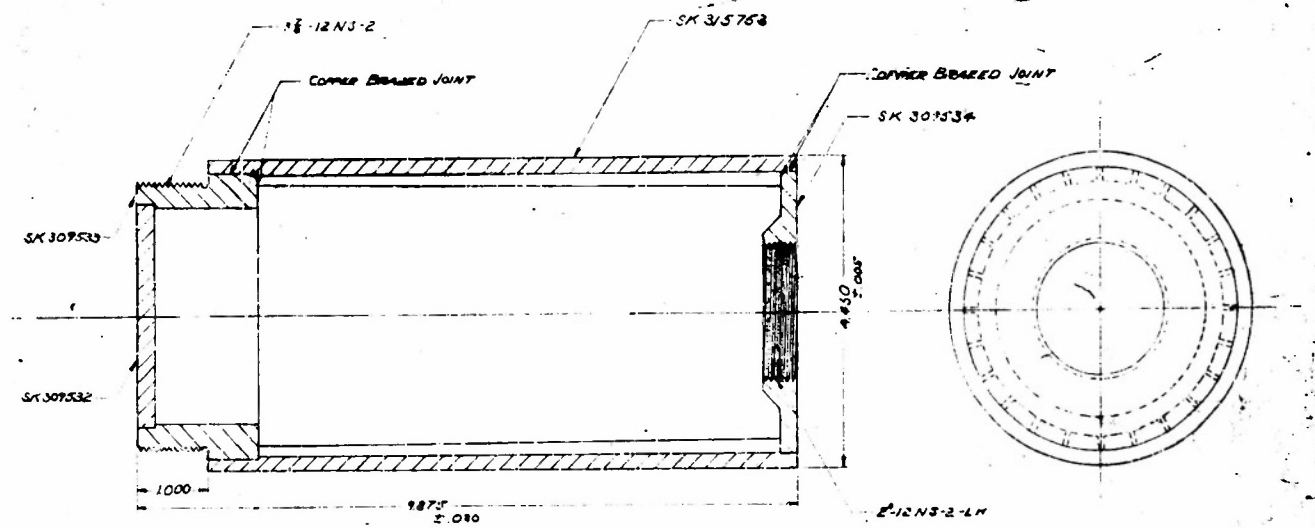
AAP TRIAL WARHEAD
TYPE No. 9
TUBE

U.S. NAVAL ORDNANCE LABORATORY

SCALE 1/1

SK 315753

SK 315753



WARHEAD IS TO BE COPPER PLATED

HEAT TREATMENT

1. QUENCH IN OIL FROM 1540°-1565°F; DRAW TO ROCKWELL 'C' 40-44
2. HEAT AND QUENCH WITH CYLINDRICAL AXIS IN VERTICAL POSITION TO MINIMIZE DISTORTION.
3. HEAT IN CONTROLLED ATMOSPHERE OR SALT BATH FURNACE TO PRODUCE SCALE FREE SURFACE.

AAP TRIAL WARHEAD
TYPE NO. 9
ASSEMBLY

SK 315754

AAP Rod-Producing Warhead and Rocket Motor, Fragmentation of

TABLE I

ANGULAR DISTRIBUTION DATA
AAP Rod-Producing Warhead and Rocket Motor
30.5 Foot Radius Arena, 15' High Panels

Rd. No. 2 Serial No. 505-2		Rd. No. 3 Serial No. 505-3		Rd. No. 4 Serial No. 505-4	
Longitude Angle (Degrees)	Fragment Length (Inches)	Longitude Angle (Degrees)	Fragment Length (Inches)	Longitude Angle (Degrees)	Fragment Length (Inches)
2	8 1/4	This round detonated		6	3 *
18	3 1/4	Low Order. See		25	8 1/4
19	3 3/4	Figure 6.		39	7 3/4
34	7			56	8
51	8			92	8
132	3			137	5
132	4			153	5 1/4
148	4 *			169	4 *
164	3 *			185	6
180	3 1/2 *				

* These fragment lengths were probably greater. They penetrated the 1" thick STS panels and the impact openings were recorded as the fragment lengths.

TABLE II

FRAGMENT VELOCITY DATA

35mm Fastax Camera
Rd. 2 NOL 505-2 AAP
30.6 foot Radius Arena
Total Weight 60.46 lbs.

3150 frames per sec.
Comp. C-3

Filler Weight 4.61 lbs.

Longitude Zone	No.	Frame in Which Hit Occurred	No. Rod-like Fragments	Velocity (f/s)
350°-55°	5	22	5	4380
125°-190°	4	23	4	4190
350°-55°	1	24	1	4020
Median				4380
Average				4270

Motor Hits

Longitude Zone			No. Motor Fragments	
350°-55°	1			
125°-190°	1	38	2	2540
350°-55°	2			
125°-190°	1	39	3	2470

AAP Rod-Producing Warheads and Rocket Motor, Fragmentation of

TABLE III

FRAGMENT VELOCITY DATA

35mm Festax Camera
Rd. 4 NOL AAP Warhead 505-4
30.6 foot Radius Arena
Total Weight 60.45 lbs.

3180 frames per sec.
Comp. C-3

Filler Weight 4.50 lbs.

Longitude Zone	No.	Frame in Which Hit Occurred	No. Rod-like Fragments	Velocity (f/s)
350°-55°	4			
125°-190°	4	24	8	4050
Average				4050

TABLE IV

MASS DISTRIBUTION DATA

FRAGMENTATION OF AAP WARHEAD SERIAL NO. 506-1 ASSEMBLED WITH MOCK-UP VT FUZE MODIFIED FOR STATIC FIRING

NUMBER AND WEIGHT OF RECOVERED FRAGMENTS

C-3 Comp. Wt. lb.	Filler Wt. lb.	0-0.625 grams Wt. Gms	No.	0.625-1.25 grams Wt. Gms	No.	1.25-2.5 grams Wt. Gms	No.	2.5-5 grams Wt. Gms	No.	5-10 grams Wt. Gms	No.	10-20 grams Wt. Gms	No.	20-40 grams Wt. Gms	No.	40-80 grams Wt. Gms	No.	80-160 grams Wt. Gms	No.	160-320 grams Wt. Gms	No.	320-640 grams Wt. Gms	No.	640-+ grams Wt. Gms	No.	TOTAL Wt. Gms	No.	* Total Wt.	Fuze Frag-ments No.	Photo. No. NPG
HEAD																														
21.70	4.60	593		193	236	178	109	263	73	364	52	383	28	576	20	1149	22	1303	11	1144	7	-	-	-	-	7178	641	1029	82	46987
MOTOR																														
**68.85	-	-		40	47	81	46	127	35	109	17	310	22	479	18	60	1	458	4	412	2	1513	3	14056	8	17645	203	-	-	46967

* Included in Total for Head

** The total recovery for the motor fragments exceeded the initial weight of the motor by 23 grams. This is explained by the fact that some of the finer head fragments were inadvertently classed as motor fragments.

FRAG NO. 1619

N.P.G. 46967

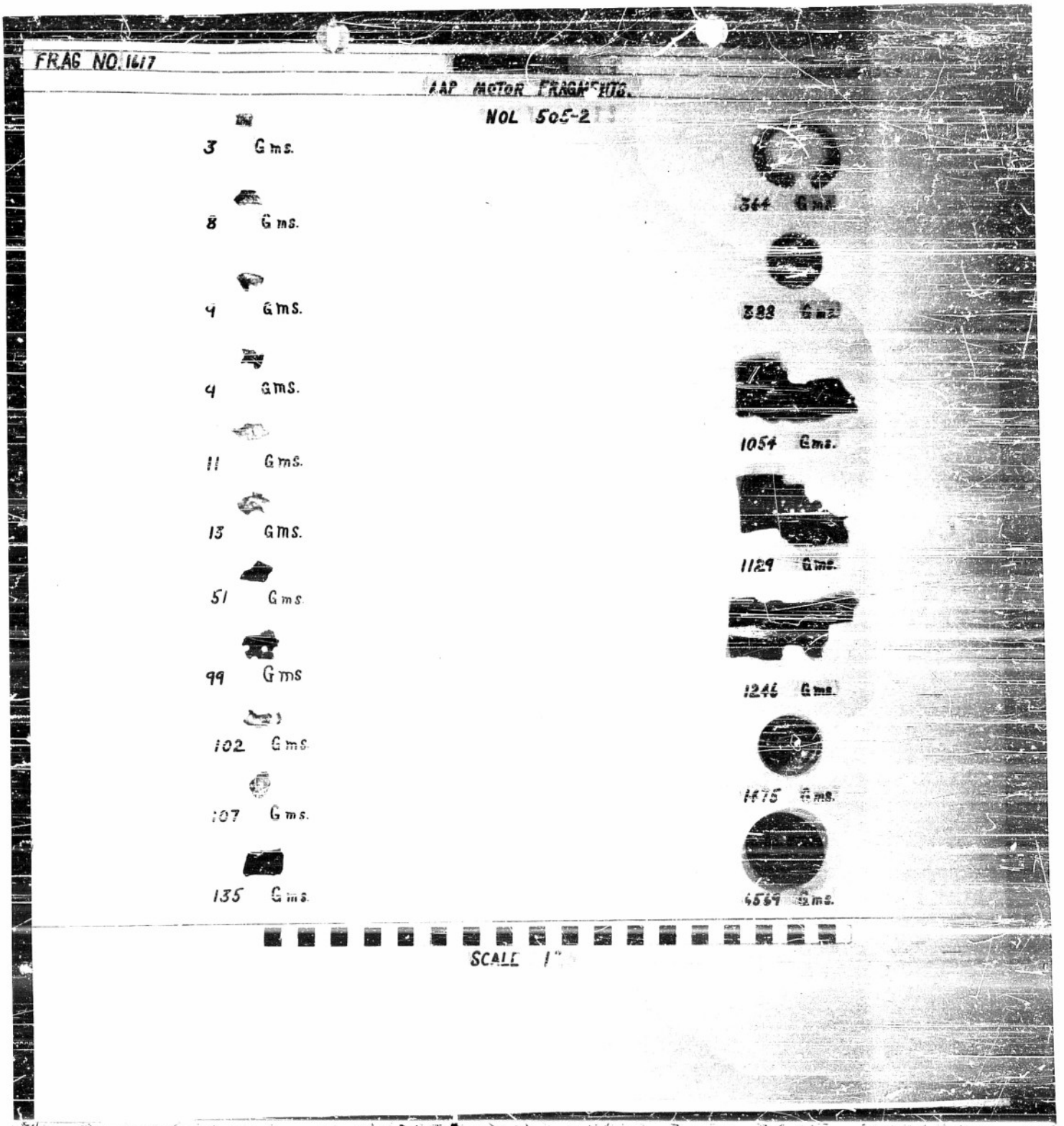
	HEAD		MOTOR
0 - ¼	Gms.		
	Pcs.		
593	Gms.		
¼ - 1¼	Gms.		
236	Pcs.		47
193	Gms.		40
1¼ - 2½	Gms.		
109	Pcs.		44
178	Gms.		81
2½ - 5	Gms.		
73	Pcs.		35
266	Gms.		127
5 - 10	Gms.		
52	Pcs.		17
364	Gms.		109
10 - 20	Gms.		
28	Pcs.		22
383	Gms.		310
20 - 40	Gms.		
20	Pcs.		18
576	Gms.		479
40 - 80	Gms.		
23	Pcs.		1
1149	Gms.		60
80 - 160	Gms.		
11	Pcs.		4
1303	Gms.		458
160 - 320	Gms.		
7	Pcs.		2
1144	Gms.		412
320 - 640	Gms.		
	Pcs.		3
	Gms.		1513
640 +	Gms.		
	Pcs.		8
	Gms.		14056
FUZE - FRAGS			
82	PCS.		
1029	Gms.		

SCALE 1"

NPG-46967 7 December 1951 CONFIDENTIAL SECURITY INFORMATION

Mass Distribution of AAP Rod-producing Warhead and Rocket Motor Serial No. 505-1.

Figure 4

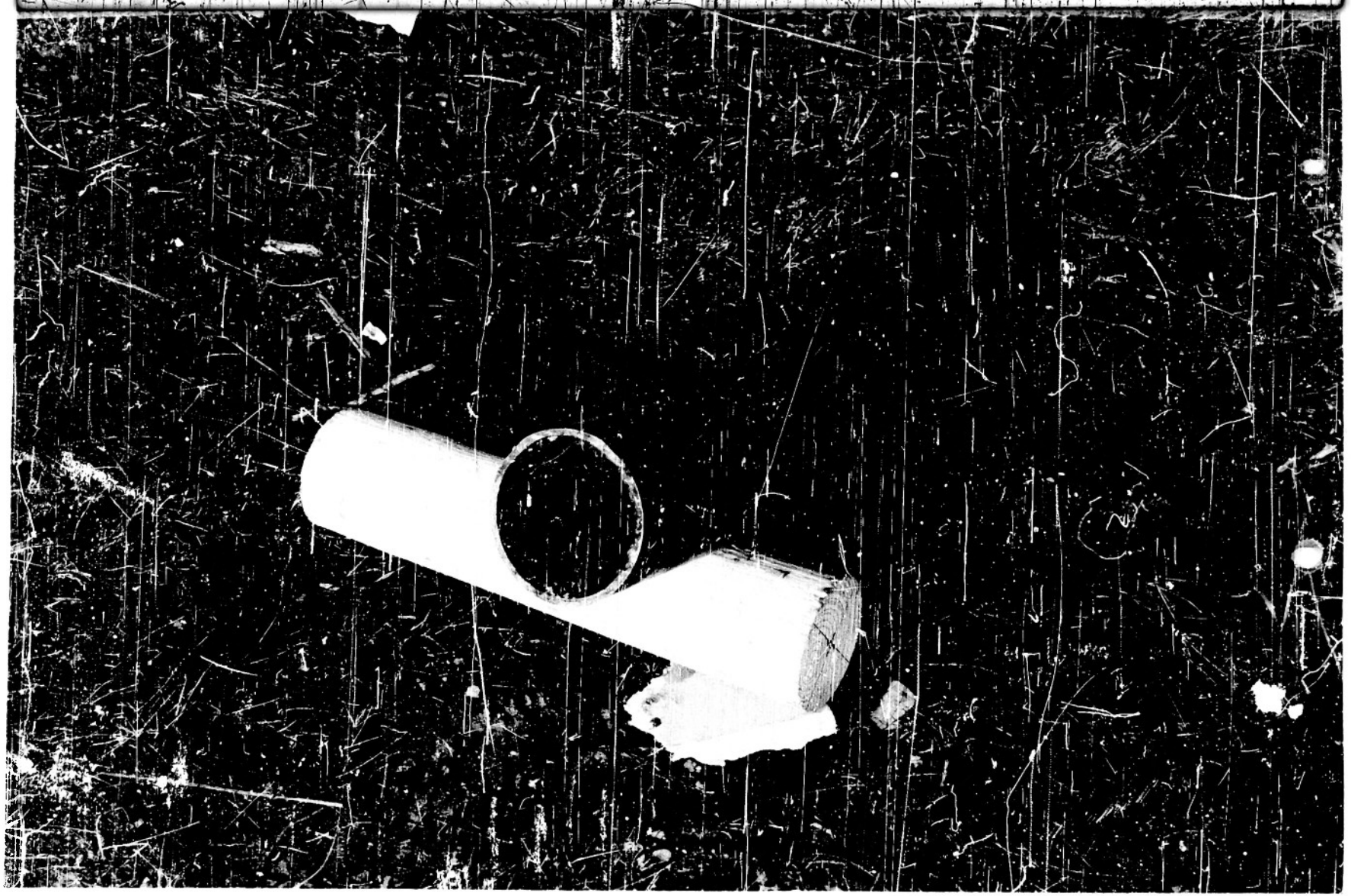


Sample Rocket Motor Fragments from AAP Serial No. 505-2 recovered in the field.

Figure 5

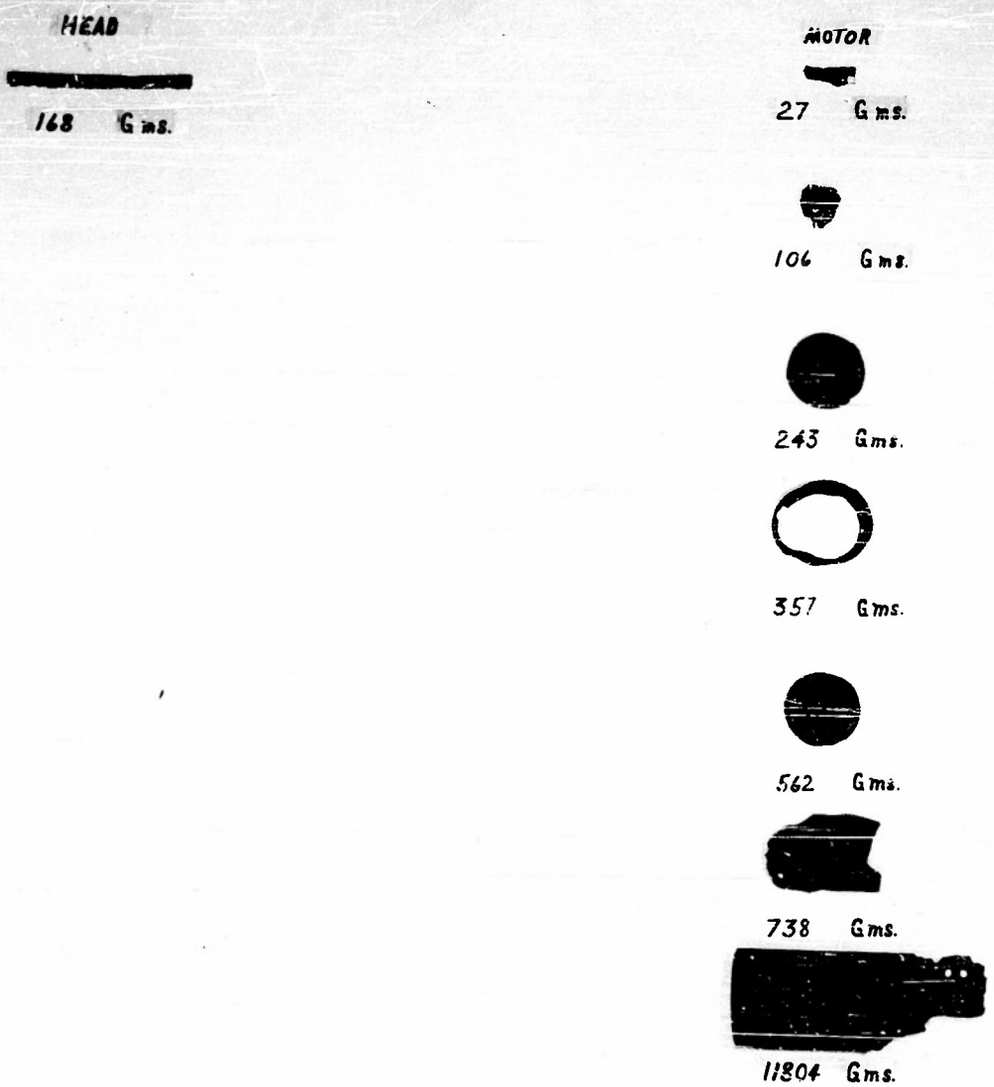
AAP Rod-producing Warhead and Rocket Motor Serial No. 515-3 after low order detonation. End plate, fuze and some Composition C-3 were blown out.

Figure 6



NP9 46256

AAP FRAGMENTS.
NOL 505-4



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Sample warhead and rocket motor fragments from AAP Serial No. 505-4 recovered in cane fiberboard and in the field.

Figure 7

AAP Rod-Producing Warheads and Rocket Motor, Fragmentation of

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